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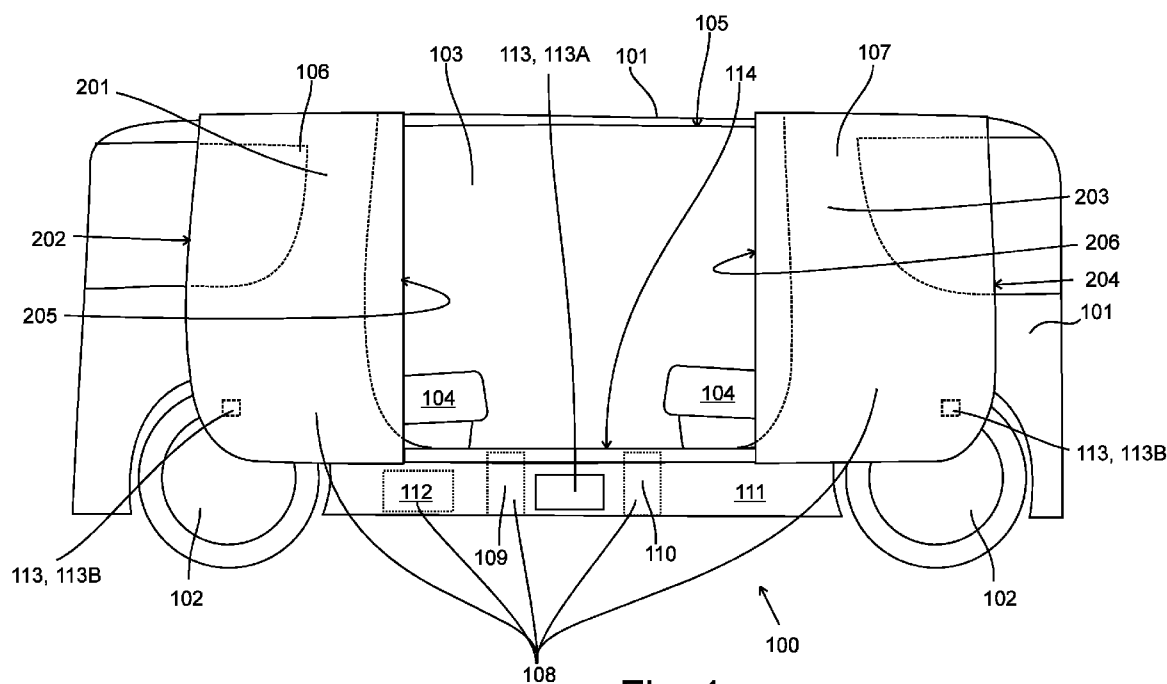


Fig. 1

(57) Abstract: Aspects of the present invention relate to a door system (108) for a vehicle (100), a vehicle (100) a method (2000) and a control system (112). The door system (108) comprises a first door (106) configured to move between a closed position, in which it covers at least a portion of an opening (105) in a body of a vehicle (100), and an open position allowing access through the opening (105) into a cabin (103) of the vehicle (100). The door system also includes a first barrier member (109), moveable between a retracted position and a barrier position where it is configured to resist entry into the cabin (103) of objects impacting against the first door (106), and a control system (112) configured to receive a sensor signal indicative of an impact and/or an expected impact on the first door (106), and to cause an actuator (501) to move the first barrier member (109) to the barrier position in dependence on receiving the sensor signal.

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A DOOR SYSTEM AND METHOD OF PROVIDING A BARRIER TO ENTRY INTO A CABIN OF A VEHICLE

TECHNICAL FIELD

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The present disclosure relates to a door system and method of providing a barrier to entry into a cabin of a vehicle. In particular, but not exclusively it relates to a door system and method of providing a barrier to entry into a cabin of a vehicle in a road vehicle for carrying passengers within the cabin.

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BACKGROUND

The safety of occupants of road vehicles, such as cars, depends partly upon the strength of the structure of the vehicle that surrounds the occupants. This includes the strength of the sides of the vehicle, which is of importance during a side impact on the vehicle. Consequently, road vehicles are known to have doors that include additional structural members to increase the ability of the doors to withstand impacts from other vehicles, thereby increasing occupant safety.

On conventional road vehicles, such as cars, passengers are able to obtain access to front seats of the cabin of the vehicle by a front door mounted on an A-pillar at the front end of the front door and may be able to obtain access to rear seats by a rear door, typically mounted on a B-pillar at the front end of the rear door, or possibly mounted on a C-pillar at the rear end of the rear door. In the event of a side impact on such a vehicle, the B-pillar positioned between the front and rear door plays a significant part in providing structural reinforcement for side impact events. In recent times, vehicle designs have been proposed that eliminate the B-pillar between front and rear doors to provide easier access into the cabin of the vehicle. However, the disadvantage of this arrangement is that it results in the front and rear doors extending across a relatively wide single opening, without the support that a B-pillar would provide to the doors in the event of a side impact on the vehicle.

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It is an aim of the present invention to address one or more of the disadvantages associated with the prior art.

SUMMARY OF THE INVENTION

Aspects and embodiments of the invention provide a door system for a vehicle, a vehicle a method and a control system as claimed in the appended claims.

5 According to an aspect of the invention there is provided a door system for a vehicle, the door system comprising: a first door configured to move between a closed position, in which it covers at least a portion of an opening in a body of a vehicle, and an open position allowing access through the opening into a cabin of the vehicle; a first barrier member moveable
10 between a retracted position and a barrier position where it is configured to resist entry into the cabin of objects impacting against the first door; and a control system configured to receive a sensor signal indicative of an impact and/or an expected impact on the first door, and to cause an actuator to move the first barrier member to the barrier position in dependence on receiving the sensor signal.

15 This provides the advantage that objects impacting the door of a vehicle may be prevented from entry into the cabin of the vehicle by the barrier member and therefore occupants of the cabin are given additional protection from side impacts on the vehicle.

Optionally, the actuator comprises a pyrotechnic device operable to cause movement of the
20 first barrier member from the retracted position to the barrier position. This provides the advantage that the barrier member may be very rapidly deployed in response to receiving a signal from the control system.

Optionally, the actuator comprises a spring configured to be loaded when the barrier member
25 is in the retracted position, and the first barrier member is moveable from its retracted position to its barrier position by releasing energy stored in the spring. This provides the advantage that the barrier member may be very rapidly deployed.

Optionally, the actuator comprises a pneumatic cylinder arranged to be actuated by a
30 compressed gas. This provides the advantage that the barrier member may be very rapidly deployed.

Optionally, the first barrier member comprises a first portion and a second portion, the first barrier member being moveable between the retracted position in which the first portion and
35 the second portion are both disposed above, or both disposed below, a floor level of the cabin,

and the barrier position in which the first portion resides below the floor level and the second portion extends up to an elevated level, above the floor level. This provides the advantage that the barrier member does not hinder the normal operation of the door as it is opened and closed, but in the event of an object impacting against the door the barrier member provides
5 a barrier extending up from the floor of the cabin to provide protection for the occupants.

Optionally, the first door comprises an outer panel and an inner panel, and, in the barrier position, the second portion is disposed between the inner panel and the outer panel. This provides the advantage that occupants of the cabin are kept safely clear of the space above
10 the floor level that the barrier member will occupy when it is deployed.

Optionally, the first door has a base panel extending between a lower end of the inner panel and the outer panel, and the base panel is configured to rupture under pressure from the first barrier member when it is moved from the retracted position to the barrier position. This
15 provides the advantage that the interior of the door, between the inner and outer panels, may be protected from the environment, while allowing the barrier member to freely move between its retracted position and barrier position.

Optionally, the cabin has a floor comprising a cover panel, and the cover panel is configured to rupture under pressure from the first barrier member when it is moved from the retracted
20 position to the barrier position. This provides the advantage that a space below the level of the floor is covered to provide occupants with an apparently continuously floor surface, while allowing the barrier member to freely move between its retracted position and barrier position in which it is partly above and partly below the level of the floor.

Optionally, the first door comprises a crosspiece extending across the width of the first door, and in the barrier position the first barrier member is configured to provide support to the crosspiece to resist lateral movement of the crosspiece into the cabin. This provides the advantage that the crosspiece provides a barrier across the door for resisting entry into the
25 cabin of objects impacting against the door, and the crosspiece is supported in its position by the barrier member. Thus, the crosspiece provides protection for the occupants of the cabin in the event of a side impact.

Optionally, the crosspiece comprises a rail, and the first door is moveable between the closed
35 position and the open position by the rail sliding on a guiding device. This provides the

advantage that the rail, which is present to enable sliding of the door, is put to a second use as a barrier.

Optionally, in the retracted position, the first portion and the second portion are both positioned below the floor level and the first portion is retained within a housing that is rigidly attached to the body of the vehicle.

Optionally, in the retracted position, the first portion and the second portion are both positioned above the floor level and the second portion is retained within a housing that is rigidly attached to the first door.

Optionally, the first barrier member is configured to move linearly between the retracted position and the barrier position. This provides the advantage that the actuator may have a simple design for rapidly deploying the barrier member.

Optionally, the first barrier member is configured to rotate between the retracted position and the barrier position. This provides the advantage that the barrier member may be located in its retracted position within a space that has very limited height compared to the height of the barrier member when it is in its barrier position.

Optionally, the sensor signal is received from a sensor configured to detect an impact on the first door. This provides the advantage that the barrier member is only deployed when the door is hit by an object.

Optionally, the sensor signal is received from a sensor configured to detect movement of objects external to the vehicle. This provides the advantage that impacts on the on the door are detected early providing more time for the deployment of the barrier member.

Optionally, the first door is supported at a first side of the opening by a first mechanism that enables the first door to move between the open position and the closed position; the door system comprises a second door supported by a second mechanism at a second side of the opening, opposite to the first side, the second mechanism being configured to enable the second door to move between a closed position, in which it covers a portion of the opening in the body of the vehicle, and an open position allowing access through the opening into the cabin of the vehicle. This provides the advantage that a large opening with two doors is

provided with barriers to resist entry into the cabin of large objects such as a part of a vehicle that might otherwise pass through the opening.

5 Optionally, in the barrier position, the first barrier member is configured to resist entry into the cabin of objects impacting against the second door.

10 Optionally, the first door comprises a first crosspiece extending across the width of the first door; the second door comprises a second crosspiece extending across the width of the second door; when the first door and the second door are in closed positions, a first end portion of the first crosspiece is aligned with a first end portion of the second crosspiece, and in the barrier position the barrier member extends along the first end portions of the first crosspiece and the second crosspiece to resist external forces acting to misalign the first end portions. This provides the advantage that the two crosspieces in combination with the barrier member form a continuous barrier extending across the width of both doors.

15 Optionally, the first crosspiece comprises a first rail for enabling the first door to slide; and the second crosspiece comprises a second rail for enabling the second door to slide. This provides the advantage that the rails, which are present to enable sliding of the doors, are put to a second use as a barrier.

20 Optionally, the door system comprises a second barrier member moveable between a retracted position and a barrier position at which the second barrier member is configured to resist entry into the cabin of objects impacting against the second door.

25 According to another aspect of the invention there is provided a vehicle comprising a cabin having an opening to enable access into the cabin and a door system according to any one of the previous claims.

30 According to a further aspect of the invention there is provided a method of providing a barrier to entry into a cabin in a body of a vehicle, the method comprising: receiving a sensor signal indicative of an impact and/or an expected impact on a first door that covers an opening into the cabin of the vehicle; and in dependence on receiving the sensor signal, providing an output signal to an actuator to cause the actuator to move a first barrier member from a retracted position to a barrier position where the first barrier member is configured to resist entry into
35 the cabin of objects impacting against the first door. This provides the advantage that objects

impacting the door of a vehicle may be prevented from entry into the cabin of the vehicle by the barrier member and therefore occupants of the cabin are given additional protection from side impacts on the vehicle.

- 5 According to yet another aspect of the invention there is provided a control system comprising at least one electronic processor having an electrical input for receiving the sensor signal and at least one electronic memory device electrically coupled to the electronic processor and having instructions stored therein, wherein the at least one processor is configured to access the at least one memory device and execute the instructions stored therein such that it is
10 operable to perform the method of a previous paragraph.

According to a yet further aspect of the invention there is provided a non-transitory computer readable medium comprising computer readable instructions that, when executed by a processor, cause performance of the method of a previous paragraph.

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Within the scope of this application it is expressly intended that the various aspects, embodiments, examples and alternatives set out in the preceding paragraphs, in the claims and/or in the following description and drawings, and in particular the individual features thereof, may be taken independently or in any combination. That is, all embodiments and/or
20 features of any embodiment can be combined in any way and/or combination, unless such features are incompatible. The applicant reserves the right to change any originally filed claim or file any new claim accordingly, including the right to amend any originally filed claim to depend from and/or incorporate any feature of any other claim although not originally claimed in that manner.

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BRIEF DESCRIPTION OF THE DRAWINGS

One or more embodiments of the invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

- 30 Fig. 1 shows a side view of a road vehicle with its doors in an open position;
Fig. 2 shows a side view of the road vehicle of Fig. 1 with its doors in a closed position;
Fig. 3 shows a rear cross-sectional view of the vehicle of Figs. 1 and 2 when it is about to undergo a side impact from another vehicle;
Fig. 4 shows Fig. 2 shows a side view of the road vehicle of Fig. 1 with its doors in a closed
35 position and with its barrier members in a barrier position;

Fig. 5 shows schematically a first example of an actuator for deploying a barrier member;
Fig. 6 shows schematically a second example of an actuator for deploying a barrier member;
Fig. 7 shows schematically a third example of an actuator for deploying a barrier member;
Fig. 8A and 8B show a cross-sectional side view and a cross-sectional front view of a barrier
5 member in its retracted position within a sill of the vehicle;
Fig. 9A and 9B show a cross-sectional side view and a cross-sectional front view of the barrier
member of Figs. 8A and 8B in its barrier position, having been deployed;
Figs. 10A and 10B show cross-sectional views of an alternative barrier member in its retracted
position and its deployed position respectively;
10 Fig. 11 shows a second vehicle embodying the present invention;
Fig. 12 shows a third vehicle embodying the present invention;
Fig. 13 shows crosspieces mounted on the inside of the outer panels of the doors of the vehicle
shown in Fig. 12, with a barrier member in a retracted position;
Fig. 14 shows the same arrangement as Fig. 13 but with the barrier member in its barrier
15 position;
Fig. 15 shows a further alternative vehicle embodying the present invention;
Fig. 16A shows in cross-section the door, the barrier member and the corresponding socket
of the vehicle shown in Fig. 15, with the barrier member in a retracted position;
Fig. 16B shows the same arrangement as Fig. 16A but with the barrier member in its barrier
20 position;
Fig. 17 shows a retracted barrier member deployable to its barrier position by rotation about a
pivot;
Fig. 18 shows the barrier member of Fig. 17 in its barrier position;
Fig. 19 shows a schematic diagram of the control system of Fig. 1; and
25 Fig. 20 shows a flowchart illustrating a method of providing a barrier to entry into a cabin in a
body of a vehicle.

DETAILED DESCRIPTION

30 A vehicle 100, a door system 108, a control system 112, a method 2000 and a non-transitory
computer readable medium 1902 in accordance with an embodiment of the present invention
is described herein with reference to the accompanying Figs. 1 to 20.

With reference to Fig. 1, the vehicle 100 is a road vehicle 100 comprising a body 101 mounted
35 on road wheels 102. The vehicle 100 has a cabin 103 in the body 101 of the vehicle 100, and

in the present embodiment, the cabin 103 contains seats 104 mounted on the floor 114 of the cabin 103 to enable occupants of the vehicle 100 to be seated.

Access to the cabin 103 is provided by an opening 105 in the side of the vehicle 100, and the opening 105 may be closed off by the doors 106 and 107 of the door system 108. In the present embodiment, the door system 108 includes two doors, namely a front door 106 and a rear door 107, but in alternative embodiments the door system 108 may comprise a single door that covers the whole of the opening 105 when it is closed.

In the present embodiment, the doors 106 and 107 are both mounted to slide between a fully open position as shown in Fig. 1 and a closed position as shown in Fig. 2. In alternative embodiments the front door 106 may be mounted on an A-pillar 201 by hinges at a leading edge 202 of the front door 106, and the rear door 107 may be mounted on a C-pillar 203 at a rear edge of the door 107.

As shown in Fig. 2, a rear edge 205 of the front door 106 abuts a front edge 206 of the rear door 107 and the two doors 106 and 107 in combination extend across the whole width of the opening 105 (illustrated by dotted line in Fig. 2). As illustrated in Fig. 1, the vehicle 100 does not have a B-pillar between the A-pillar 201 and the C-pillar 203, and therefore the two doors 106 and 107 are not provided with the support of a B-pillar.

The door system 108 also comprises two barrier members 109 and 110, which in the present embodiment are located within a sill 111 extending along the lower ends of the two doors 106 and 107, and a control system 112 configured to cause the deployment of the barrier members 109 and 110 in the event of a side impact. In Figs. 1 and 2, the barrier members 109 and 110 are in a retracted position, in which they are totally concealed within the sill 111 and below the level of the floor 114. Therefore the barrier members 109 and 110 do not impede people entering or leaving the cabin 103 and they also do not impede the movement of the doors 106 between the open position of Fig. 1 and the closed position of Fig. 2.

The control system 112 is configured to receive a sensor signal indicative of an impact and/or an expected impact on the front door 106 and/or the rear door 107 from one or more sensors 113A and 113B and, in dependence on receiving such a sensor signal, provide an output signal to cause the deployment of the barrier members 109 and 110.

One or more of the sensors 113A may be mounted within the sill 111 and configured to detect objects that are very likely to impact on one or both of the doors 106 and 107. In the present embodiment, one of the sensors 113A, which is mounted within the sill 111, is a radar sensor 113A capable of tracking objects in the vicinity of the vehicle 100. The radar sensor may be configured to provide the processing necessary to track objects, determine when such objects are very likely to impact against the side of the vehicle 100, and then notify the control system 111 when an impact is imminent. Alternatively, the radar sensor 113A may be configured to provide a signal to the control system 112 providing information relating to objects being tracked and the determination of when such an object is very likely to impact against the side of the vehicle 100 may be determined by the control system 112. In dependence on receiving a signal from the radar sensor 113A indicating that an object is very likely to impact against one of the doors 106 and 107, the control system 112 causes the barrier members 109 and 110 to be deployed.

In an alternative embodiment, the sensors 113A configured to detect objects external to the vehicle 100 may comprise a lidar sensor, an ultrasonic sensor or other sensor capable of remotely sensing external objects.

In the present embodiment, the vehicle 100 also includes sensors 113 in the form of microphones 113B mounted on each of the doors 106 and 107 and which provide electronic signals to the control system 112 indicative of acoustic signals they receive. The control system 112 is configured to process signals received from the microphones 113B and detect when they have generated a signal indicative of an impact on one or both of the doors 106 and 107. In the event of such an impact being detected from the signals received from the microphones 113B, the control system 112 is configured to cause the barrier members 109 and 110 to be deployed.

The vehicle 100 is shown again in the rear cross-sectional view of Fig. 3 and the side view of Fig. 4 after deployment of the barrier members 109 and 110. The barrier members 109 and 110 on the left side of the vehicle 100 are shown in their barrier positions in Figs. 3 and 4. It may be noted that the right side of the vehicle 100 may have a similar configuration to the left side of the vehicle 100, but as illustrated in Fig. 3, the barrier members 109 and 110 corresponding to the right side of the vehicle 100 are in their retracted positions.

Fig. 3 also shows the front end of a van 301 which is about to impact against the doors 106 and 107 on the left side of the vehicle 100.

Each of the barrier members 109 and 110 is supported within a housing 401 that is rigidly fixed within the sill 111. When the barrier members 109 and 110 are in their barrier positions, shown in Figs. 3 and 4, a first portion 402 of the barrier members 109 and 110 remains below the level of the floor 114 and is retained within the housing 401 but a second portion 403 extends upwards from the level of the floor 114 to an elevated level 303. The doors 106 and 107 each have an outer panel 302, and the second portion 403 of each of the barrier members 109 and 110 extends upwards alongside the outer panel 302 of a corresponding one of the doors 106 and 107, so that each of the second portions 403 are positioned between the outer panel 302 of one of the doors 106 and 107 and the cabin 103.

When the front end of the van 301 impacts on the doors 106 and 107, the doors may bend and/or break but the barrier members 109 and 110 supported by their housings 401 resist entry into the cabin 103 of the front end of the van 301. For example, the action of the van 301 against the barrier members 109 and 110 may cause the vehicle 100 to be pushed sideways rather than the front of the van 301 entering the space within the cabin 103. Consequently occupants, such as the person 304, within the cabin 103 are not hit by the van 301.

It will be appreciated that due to the high speed with which vehicles such as the van 301 may impact against the doors 106 and 107, the periods of time between a determination that a vehicle is very likely to impact against the doors 106 and 107 and the time at which that vehicle reaches the barrier members 109 and 110 is short. Also the period of time between a vehicle hitting one of the doors 106 and 107 reaching the barrier members 109 and 110 is even shorter. However, the barrier members 109 and 110 are provided with actuators capable of deploying the barrier members 109 and 110 from the retracted positions of Figs. 1 and 2 to the barrier positions of Figs. 3 and 4 sufficiently rapidly.

A first example of an actuator 501 for deploying the barrier member 109 is shown schematically in Fig. 5. (It will be appreciated that the barrier member 110 may be deployed by similar actuator 501.) In this example, the housing 401 provides a close fitting sleeve around the barrier member 109 and the actuator 501 comprises pyrotechnic device 501A located between the barrier member 109 and a closed end 502 of the sleeve. The pyrotechnic device 501A is configured to force the barrier member 109 from its retracted position, illustrated in

Fig. 5 to its barrier position (shown in dashed outline) on receipt of an electrical signal from the control system 112.

A second example of an actuator 501 for deploying the barrier member 109 is shown schematically in Fig. 6. In this example, the actuator 501 comprises a loaded spring 501B configured to force the barrier member 109 from its retracted position, illustrated in Fig. 6 to its barrier position (shown in dashed outline) when the energy stored in the spring 501B is released. The spring 501B is maintained in its loaded configuration by a latching means 601 that is configured to allow the energy stored in the spring 501B to be released on receipt of an electrical signal from the control system 112. The latching means 601 may comprise a pyrotechnically actuated latch or a pyrotechnic fastener, such as a nut or bolt.

A third example of an actuator 501 for deploying the barrier member 109 is shown schematically in Fig. 7. In this example, the actuator 501 comprises a pneumatic cylinder 501C comprising a piston 703 configured to push the barrier member 109 to its barrier position (shown in dashed outline) when operated. The pneumatic cylinder 501C is connected to a high pressure gas container 701 via an electrically operable valve 702. The valve 702 is configured to remain in its closed position until it receives an electrical signal from the control system 112 causing it to open and thereby cause the actuation of the pneumatic cylinder 501C.

The barrier member 109 is shown positioned within the sill 111 in a cross-sectional side view in Figs. 8A and 9A and a cross-sectional front view in Figs. 8B and 9B. The barrier member 109 is located within its housing 401, and the housing 401 is rigidly attached to the body 101 of the vehicle 100 by a bracket 800.

The entire barrier member 109 is positioned below the level of the floor 114 in its retracted position of Figs. 8A and 9A. The floor 114 comprises a floor panel 801 that is positioned directed above the barrier member 109. The floor panel 801 is formed of a tough but deformable material such as a polymeric material and it has a groove 802 that provides the panel 801 with a line of weakness such that, when the barrier member 109 is forced towards its barrier position by the actuator 501, the barrier member 109 is able to break through the panel 801 to the barrier position.

In the present embodiment the door 106 comprises an inner panel 803 which generally extends parallel to the outer panel 302. The door 106 also includes a base panel 804 extending between a lower end of the inner panel 803 and the outer panel 302. The base panel 804 has a similar structure to that of the floor panel 801 and therefore it is configured to rupture under pressure from the barrier member 109 when it is moved from the retracted position to the barrier position.

As illustrated in Figs. 9A and 9B, the first portion 402 of the barrier member 109 remains below the level of the floor 114 when it is moved to its barrier position but the second portion 403 is positioned above the level of the floor 114 between the inner panel 803 and the outer panel 302.

An alternative barrier member 109A is shown in its retracted position and its deployed position respectively in the cross-sectional views of Figs. 10A and 10B. The barrier member 109A is U-shaped, having a cross bar 1001 extending between two legs 1002. The barrier member 109A is supported by a housing 401A, which comprises two guides 1003 each of which contains one of the legs 1002 of the barrier member 109A such that the barrier member is able to slide from its retracted position shown in Fig 10A to its barrier position shown in Fig. 10B. In order to deploy the barrier member 109A each of the legs 1002 has an associated actuator 501 configured to push against the legs 1002 in response to a signal from the control system 112. The actuators 501 may be as described above in respect of Figs. 5 to 7. The construction of the barrier member 109A along with the housing 401A and actuators 501 may be similar to those known for use when providing deployable roll-bars on convertible cars.

A second vehicle 100 embodying the present invention is shown in Fig. 11. The vehicle 100 of Fig. 11 has all of the features described above for the vehicle 100 shown in Figs. 1 to 4. In addition the vehicle 100 of Fig. 11 comprises doors 106 and 107 that each have a respective crosspiece 1101 extending horizontally across their width. The crosspieces 1101 extend above the level of the floor 114 of the cabin 103 at equal heights so that they are substantially aligned with each other. The crosspieces 1101 may be rigidly attached to the outer panels 302 of the doors 106 and 107 and formed of a material that provides additional strength to the doors. For example, the crosspieces 1101 may be formed of a metal, such as steel, or a fibre composite material.

The doors 106 and 107 are attached to the body 101 of the vehicle 100 by mechanisms 1102 that enable the doors to move between their closed positions shown in Fig. 11 and their open positions allowing access into the cabin 103.

5 In some embodiments, in which the doors 106 and 107 are sliding doors, the crosspieces 1101 are rails and the mechanisms 1102 comprise guides that locate within the rails so that the rails are able to slide over the guides. In such embodiments, the mechanisms 1102 may also comprise electric motors configured to drive the rails with respect to the body 101 in order to open and close the doors 106 and 107.

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In alternative embodiments, the mechanisms 1102 comprise hinges defining axes about which the doors 106 and 107 can rotate to open and close. In such embodiments, the crosspiece 1101 of each door 106 and 107 extends from the hinge 1102 of that door and across its width to provide it with additional strength.

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The vehicle 100 of Fig. 11 also comprises barrier members 109 and 110 as described previously for the vehicle 100 of Figs. 1 to 4. The barrier members 109 and 110 are shown in their barrier positions in Fig. 11 having been deployed by the control system 112. In their barrier positions, the barrier members 109 and 110 extend from below the level of the floor 20 114 up to an elevated level 303 that is above a lower edge 1103 of the crosspieces 1101, so that the crosspieces 1101 are sandwiched between the outer panel 302 of the doors 106 and 107 and one of the barrier members 109 and 110. Consequently, in the event of a side impact on the vehicle 100 of Fig. 11, the crosspieces 1101 are supported by the barrier members 1101 and the mechanisms 1102 (whether hinges or rail guides) to resist lateral movement of 25 the crosspieces 1101 into the cabin. Thus, the crosspieces provide an extended barrier for preventing objects from entering though the opening 105 into the cabin 103.

In an alternative arrangement, a single deployable barrier member 109E may be provided which extends along end portions of the crosspiece 1101 on each of the doors 106 and 107 30 to provide support to both doors. The single barrier member 109E may be deployed from its retracted position in the sill of the vehicle 100 as described above for barrier members 109 and 110 to its barrier position illustrated in Fig. 11. The single barrier member 109E may be provided in place of the two barrier members 109 and 110, or alternatively it may be provided in addition to the two barrier members 109 and 110.

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A third vehicle 100 embodying the present invention is shown in Fig. 12. The vehicle 100 of Fig. 12 has all of the features described above for the vehicle 100 shown in Fig. 11, except that instead of having barrier members 109 located within the sill 111 of the vehicle 100, it has a deployable barrier member 109B that is mounted to slide on the crosspieces 1101 of the doors 106 and 107.

Figs. 13 and 14 shows the crosspieces 1101 mounted on the inside of the outer panels 302 of the doors 106 and 107 of the vehicle 100 of Fig. 12. In this embodiment, the barrier member 109B comprises a sleeve that has an inner surface configured to be a good fit around, and to slide along, the crosspieces 1101 of the doors 106 and 107. In the retracted position, shown in Fig. 13, the barrier member 109B is positioned over an end portion 1301 of the crosspiece 1101 of the rear door 107 so that the barrier member 109B does not extend past the front edge 206 of the rear door 107.

The barrier member 109B has an associated actuator 501 that is configured to drive the barrier member 109B along the crosspiece 1101 of the rear door 107 to its barrier position shown in Fig. 14. In the barrier position, the barrier member 109B is positioned partly over each of the end portions 1301 of the two crosspieces 1101. The actuator 501 may be configured to function as described with reference to the actuators of Figs. 5 to 7. However, the actuator 501 illustrated in Figs. 13 and 14 is mounted on the outer door panel 302 of door 107 alongside the crosspiece 1101 and moves the barrier member 109B via an arm 1302. In embodiments in which the crosspiece 1101 is a rail on which the door 107 slides, this arrangement keeps the rail free to slide over the guide provided by the mechanism 1102.

Like previously described embodiments, the actuator 501 of Figs. 13 and 14 is controlled by the control system (112 shown in Fig. 12) to drive the barrier member 109B to its barrier position only when sensor signals indicate that an object has impacted, or is expected to impact, the door 106 and/or the door 107.

In the event of an object impacting against one of both of the doors 106 and 107, the end portions 1301 of the crosspieces 1101 are maintained in alignment by the deployed barrier member 109B. Consequently, the two crosspieces 1101 in combination with the barrier member 109B provide an elongate barrier, that is supported at each of its ends by the mechanisms 1102, and which resists entry into the cabin 103 of the impacting object.

In a similar, but alternative arrangement to that of Figs. 13 and 14, the barrier member 109B is located within a bore in the end portion 1301 of one of the crosspieces 1101 when it is in its retracted position, and the other crosspiece 1101 has a bore providing a socket for receiving a part of the barrier member 109B when it is in its barrier position.

5

A further alternative vehicle 100 embodying the present invention is shown in Fig. 15. The vehicle 100 of Fig. 15 comprises all of the features described above for the vehicle 100 of Figs. 1 to 4, except that the barrier members 109C and 110C are not mounted within the sill 111 of the vehicle 100 as was the case in Fig. 1. Instead the barrier members 109C and 110C of Fig. 15 are mounted on the inner side of the outer door panels 302 of the doors 106 and 107, so that in their retracted positions the whole of the barrier members 109C and 110C are positioned above the level of the floor 114 of the cabin 103. A socket 1501 is provided in the sill 111 below each of the retracted barrier members 109C and 110C. The sockets 1501 are configured to receive a first portion 402 of the barrier members when they are deployed.

15

The door 106, the barrier member 109C and the corresponding socket 1501 are shown in cross-section in Figs. 16A and 16B. The barrier member 109C is shown in its retracted position in Fig. 16A and its barrier position in Fig. 16B. The barrier member 109C is located within a housing 401 along which it is configured slide to its barrier position when driven by an actuator 501. In the present embodiment, the door 106 includes an inner panel 803, and the housing 401 is rigidly attached to the outer panel 302 of the door 106 between the inner panel 803 and the outer panel 302.

20

The door 106 is provided with a base panel 804 extending between its inner panel 803 and outer panel 302, and the floor 114 comprises a floor panel 801. Both the base panel 804 and the floor panel 801 are positioned directly below the barrier member 109C when in its retracted position, and both are configured to rupture under pressure of the barrier member 109C when it is driven to its barrier position by the actuator 501. The base panel 804 and the floor panel 801 may therefore be similar to those described with respect to Fig. 8A and 8B.

25

In its barrier position (shown in Fig. 16B) a first portion 402 of the barrier member 109C extends below the level of the floor 114 and is received within the socket 1501, which may be a part of the sill 111 or a separate item that is fixed within the sill 111. With the first portion 402 anchored in the socket 1501, a second portion 403 of the barrier member 109C remains above

30

the level of the floor 114 and provides a barrier to objects that impact the door 106 and resists their entry into the cabin 103 of the vehicle 100.

The barrier members described above are deployable by a linear movement from the retracted position to their barrier position. However, other barrier member arrangements are envisaged in which a retracted barrier member is deployed to its barrier position by rotation about an axis. This may be achieved using similar actuation means as described with regard to Figs. 5 to 7 but with a mechanism between the linear actuator and the barrier member to convert the linear motion to a rotational motion. An example of such an arrangement is shown in Figs. 17 and 18, where a linear actuator 501 actuates a pivotally mounted barrier member 109D. The barrier member 109D is mounted on a pivot pin 1701 and comprises a barrier portion 1702 and a crank portion 1703. The barrier portion 1702 extends substantially horizontally from the pivot pin 1701 when the barrier member is in its retracted position shown in Fig. 17 and a crank portion 1703 extends at an oblique angle to the barrier portion 1702. The free end 1706 of the crank portion 1703 is pivotally connected to one end of a connecting rod 1704 that has an opposite end pivotally connected to a piston part 1705 of the linear actuator 501.

When the linear actuator 501 is operated, the piston part 1705 of the linear actuator 501 pushes on the crank portion 1703 of the barrier member 109D via the connecting rod 1704, causing the barrier member 109D to rotate until the barrier portion 1702 of the barrier member 109D extends substantially vertically upwards from the pivot pin 1701 in its barrier position shown in Fig. 18.

An advantage of this rotational movement is that the retracted barrier member 109D may be located in a space that has a height 1707 (shown in Fig. 17) that is shorter than the length 1708 of the barrier member 109D.

A schematic diagram of the control system 112 shown in Fig. 1 is shown in Fig. 19. In the present embodiment the control system 112 comprises a single processor 1901 but, in other embodiments of the invention the control system 112 may comprise more than one processor 1901. The control system 112 comprises at least one electronic memory device 1902, having instructions 1903 stored therein, and the electronic processor 1901 is electrically coupled to the at least one electronic memory device 1902, so that it can access the instructions 1903.

The control system 112 comprises an electrical input 1904 for receiving signals from the sensors 113 and an electrical output 1905 for providing output signals to the actuator 501 to cause actuation of the barrier members 109 and 110.

- 5 The processor 1901 is configured to access the instructions 1903 stored in the memory device 1902 and execute the instructions so that it is operable to perform the functions as described previously and as summarised in the flowchart of Fig. 20.

10 Fig. 20 shows a flowchart illustrating a method 2000 of providing a barrier to entry into a cabin 103 of a vehicle 100. The method 2000 is performable by the control system 112. At block 2001 of the method 2000, a sensor signal indicative of an impact and/or an expected impact on a first door 106 that covers an opening 105 into the cabin 103 of the vehicle 100 is received.

15 As described above, the sensor signal may for example comprise an electrical signal representative of an audio signal received by a microphone 113B that is configured to sense noise in the first door 106. In such an arrangement, the method additionally comprises analysing the electrical signal to detect a waveform indicative of an impact on the door. Alternatively, the analysis may be performed by another processing device associated with the sensor 113B, and the sensor signal received at block 2001 (for example by the control
20 system 112) may simply indicate that an impact has occurred.

As a further alternative, the received sensor signal may be from a sensing device 113A, such as a radar device, that is arranged to sense and track objects that are external to the vehicle 100. The signals received at block 2001 may therefore provide information defining paths of
25 tracked objects, and the method additionally comprises determining when a path of a tracked object is very likely, i.e. expected, to impact the door. Alternatively, a processing device associated with the sensing device may be configured to analyse the detected paths of the tracked objects and determine if such an impact is expected to occur, and the sensor signal received at block 2001 may simply indicate that an impact is expected.

30

At block 2002 of the method 2000, in dependence on receiving the sensor signal at block 2001, an output signal is provided to an actuator 501 to cause the actuator to move a first barrier member 109 from a retracted position to a barrier position where the first barrier member is configured to resist entry into the cabin 103 of objects impacting against the first
35 door 106.

For purposes of this disclosure, it is to be understood that the control system 112 described herein can comprise a control unit or computational device having one or more electronic processors. A vehicle and/or a system thereof may comprise a single control unit or electronic controller or alternatively different functions of the control system may be embodied in, or hosted in, different control units or controllers. A set of instructions could be provided which, when executed, cause said controller(s) or control unit(s) to implement the control techniques described herein (including the described method(s)). The set of instructions may be embedded in one or more electronic processors, or alternatively, the set of instructions could be provided as software to be executed by one or more electronic processor(s). For example, a first controller may be implemented in software run on one or more electronic processors, and one or more other controllers may also be implemented in software run on or more electronic processors, optionally the same one or more processors as the first controller. It will be appreciated, however, that other arrangements are also useful, and therefore, the present disclosure is not intended to be limited to any particular arrangement. In any event, the set of instructions described above may be embedded in a computer-readable storage medium (e.g., a non-transitory computer-readable storage medium) that may comprise any mechanism for storing information in a form readable by a machine or electronic processors/computational device, including, without limitation: a magnetic storage medium (e.g., floppy diskette); optical storage medium (e.g., CD-ROM); magneto optical storage medium; read only memory (ROM); random access memory (RAM); erasable programmable memory (e.g., EPROM and EEPROM); flash memory; or electrical or other types of medium for storing such information/instructions.

It will be appreciated that various changes and modifications can be made to the present invention without departing from the scope of the present application.

The blocks illustrated in Fig. 20 may represent steps in a method and/or sections of code in the computer program 1903. The illustration of a particular order to the blocks does not necessarily imply that there is a required or preferred order for the blocks and the order and arrangement of the block may be varied. Furthermore, it may be possible for some steps to be omitted.

Although embodiments of the present invention have been described in the preceding paragraphs with reference to various examples, it should be appreciated that modifications to

the examples given can be made without departing from the scope of the invention as claimed. For example, each of the doors 106 and 107 may have associated with it two or more deployable barrier members, rather than just one.

- 5 Features described in the preceding description may be used in combinations other than the combinations explicitly described.

Although functions have been described with reference to certain features, those functions may be performable by other features whether described or not.

10

Although features have been described with reference to certain embodiments, those features may also be present in other embodiments whether described or not.

- 15 Whilst endeavoring in the foregoing specification to draw attention to those features of the invention believed to be of particular importance it should be understood that the Applicant claims protection in respect of any patentable feature or combination of features hereinbefore referred to and/or shown in the drawings whether or not particular emphasis has been placed thereon.

CLAIMS

1. A door system for a vehicle, the door system comprising:

a first door configured to move between a closed position, in which it covers at least a portion of an opening in a body of a vehicle, and an open position allowing access through the opening into a cabin of the vehicle;

a first barrier member moveable between a retracted position and a barrier position where it is configured to resist entry into the cabin of objects impacting against the first door; and

a control system configured to receive a sensor signal indicative of an impact and/or an expected impact on the first door, and to cause an actuator to move the first barrier member to the barrier position in dependence on receiving the sensor signal.

2. A door system according to claim 1, wherein the actuator comprises a pyrotechnic device operable to cause movement of the first barrier member from the retracted position to the barrier position.

3. A door system according to claim 1 or claim 2, wherein the actuator comprises a spring configured to be loaded when the barrier member is in the retracted position, and the first barrier member is moveable from its retracted position to its barrier position by releasing energy stored in the spring.

4. A door system according to claim 1 or claim 2, wherein the actuator comprises a pneumatic cylinder arranged to be actuated by a compressed gas.

5. A door system according to any one of claims 1 to 4, wherein the first barrier member comprises a first portion and a second portion, the first barrier member being moveable between the retracted position in which the first portion and the second portion are both disposed above, or both disposed below, a floor level of the cabin, and the barrier position in which the first portion resides below the floor level and the second portion extends up to an elevated level, above the floor level.

6. A door system according to claim 5, wherein the first door comprises an outer panel and an inner panel, and, in the barrier position, the second portion is disposed between the inner panel and the outer panel.

7. A door system according to claim 5 or claim 6, wherein the first door has a base panel extending between a lower end of the inner panel and the outer panel, and the base panel is configured to rupture under pressure from the first barrier member when it is moved from the retracted position to the barrier position.

8. A door system according to any one of claims 5 to 7, wherein the cabin has a floor comprising a cover panel, and the cover panel is configured to rupture under pressure from the first barrier member when it is moved from the retracted position to the barrier position.

9. A door system according to any one of claims 5 to 8, wherein the first door comprises a crosspiece extending across the width of the first door, and in the barrier position the first barrier member is configured to provide support to the crosspiece to resist lateral movement of the crosspiece into the cabin.

10. A door system according to claim 9, wherein the crosspiece comprises a rail, and the first door is moveable between the closed position and the open position by the rail sliding on a guiding device.

11. A door system according to any one of claims 5 to 10, wherein, in the retracted position, the first portion and the second portion are both positioned below the floor level and the first portion is retained within a housing that is rigidly attached to the body of the vehicle.

12. A door system according to any one of claims 5 to 10, wherein, in the retracted position, the first portion and the second portion are both positioned above the floor level and the second portion is retained within a housing that is rigidly attached to the first door.

13. A door system according to any one of claims 1 to 12, wherein the first barrier member is configured to move linearly between the retracted position and the barrier position.

14. A door system according to any one of claims 1 to 12, wherein the first barrier member is configured to rotate between the retracted position and the barrier position.

15. A door system according to any one of claims 1 to 14, wherein the sensor signal is received from a sensor configured to detect an impact on the first door.

16. A door system according to any one of claims 1 to 15, wherein the sensor signal is received from a sensor configured to detect movement of objects external to the vehicle.

5 17. A door system according to any one of claims 1 to 16, wherein:

the first door is supported at a first side of the opening by a first mechanism that enables the first door to move between the open position and the closed position;

10 the door system comprises a second door supported by a second mechanism at a second side of the opening, opposite to the first side, the second mechanism being configured to enable the second door to move between a closed position, in which it covers a portion of the opening in the body of the vehicle, and an open position allowing access through the opening into the cabin of the vehicle.

15 18. A door system according to claim 17, wherein, in the barrier position, the first barrier member is configured to resist entry into the cabin of objects impacting against the second door.

19. A door system according to claim 17 or claim 18, wherein:

20 the first door comprises a first crosspiece extending across the width of the first door;
the second door comprises a second crosspiece extending across the width of the second door;

25 when the first door and the second door are in closed positions, a first end portion of the first crosspiece is aligned with a first end portion of the second crosspiece, and in the barrier position the first barrier member extends along the first end portions of the first crosspiece and the second crosspiece to resist external forces acting to misalign the first end portions.

20. A door system according to claim 19, wherein:

30 the first crosspiece comprises a first rail for enabling the first door to slide; and
the second crosspiece comprises a second rail for enabling the second door to slide.

21. A door system according to any one of claims 17 to 20, wherein the door system comprises a second barrier member moveable between a retracted position and a barrier position at which the second barrier member is configured to resist entry into the cabin of
35 objects impacting against the second door.

22. A vehicle comprising a cabin having an opening to enable access into the cabin and a door system according to any one of the previous claims.

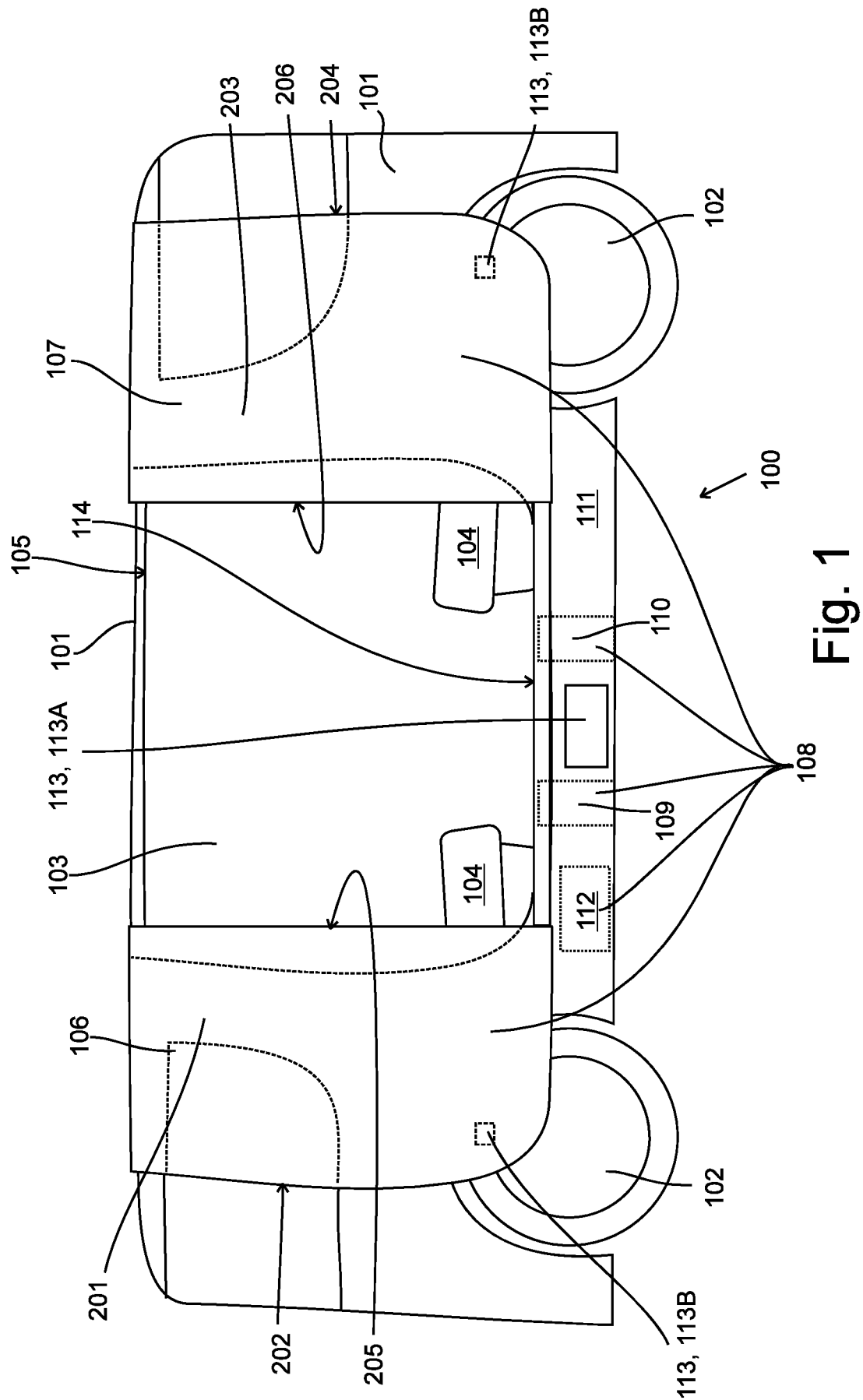
5 23. A method of providing a barrier to entry into a cabin in a body of a vehicle, the method comprising:

receiving a sensor signal indicative of an impact and/or an expected impact on a first door that covers an opening into the cabin of the vehicle; and

10 in dependence on receiving the sensor signal, providing an output signal to an actuator to cause the actuator to move a first barrier member from a retracted position to a barrier position where the first barrier member is configured to resist entry into the cabin of objects impacting against the first door.

24. A control system comprising at least one electronic processor having an electrical input
15 for receiving the sensor signal and at least one electronic memory device electrically coupled to the electronic processor and having instructions stored therein, wherein the at least one processor is configured to access the at least one memory device and execute the instructions stored therein such that it is operable to perform the method of claim 23.

20 25. A non-transitory computer readable medium comprising computer readable instructions that, when executed by a processor, cause performance of the method of claim 23.



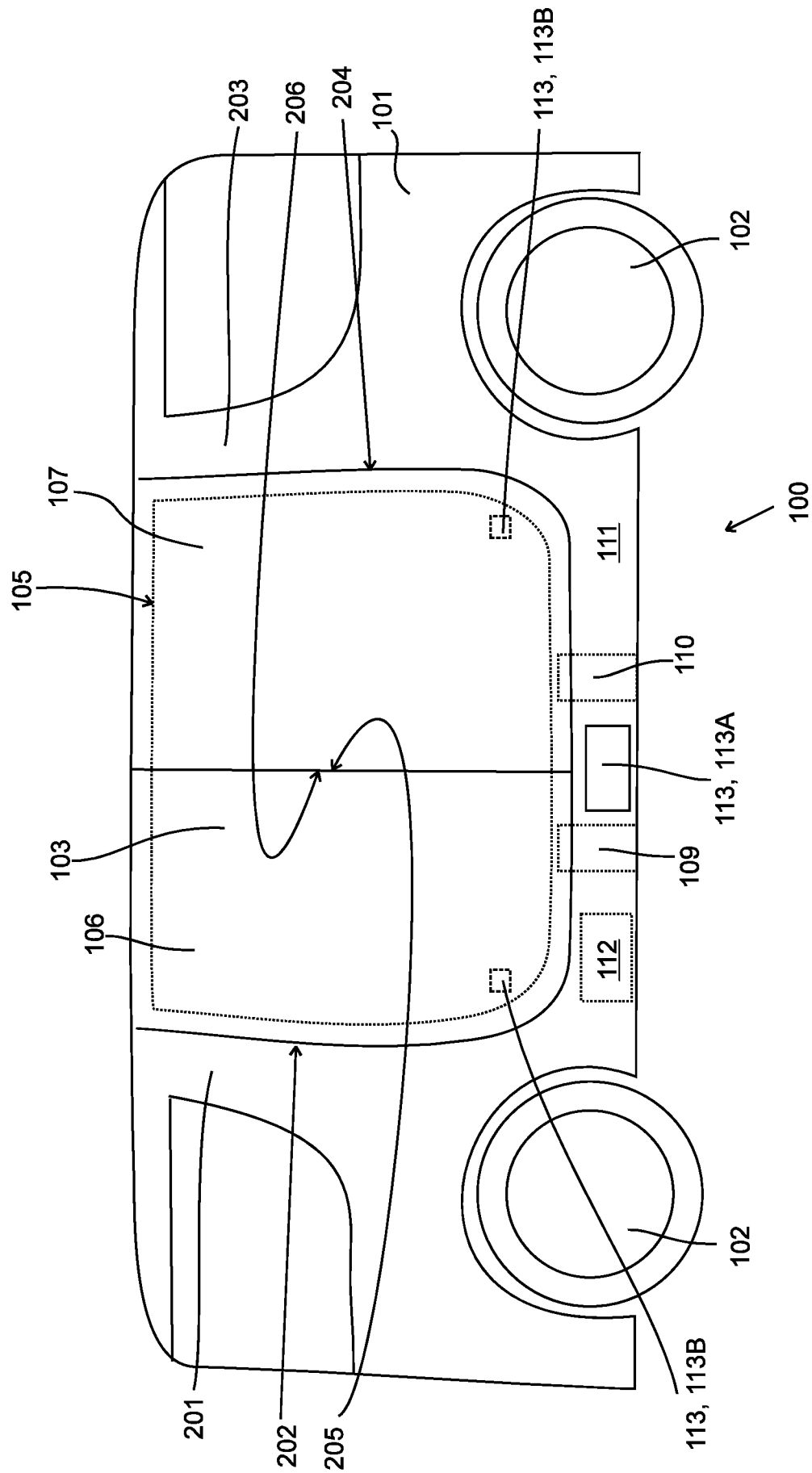


Fig. 2

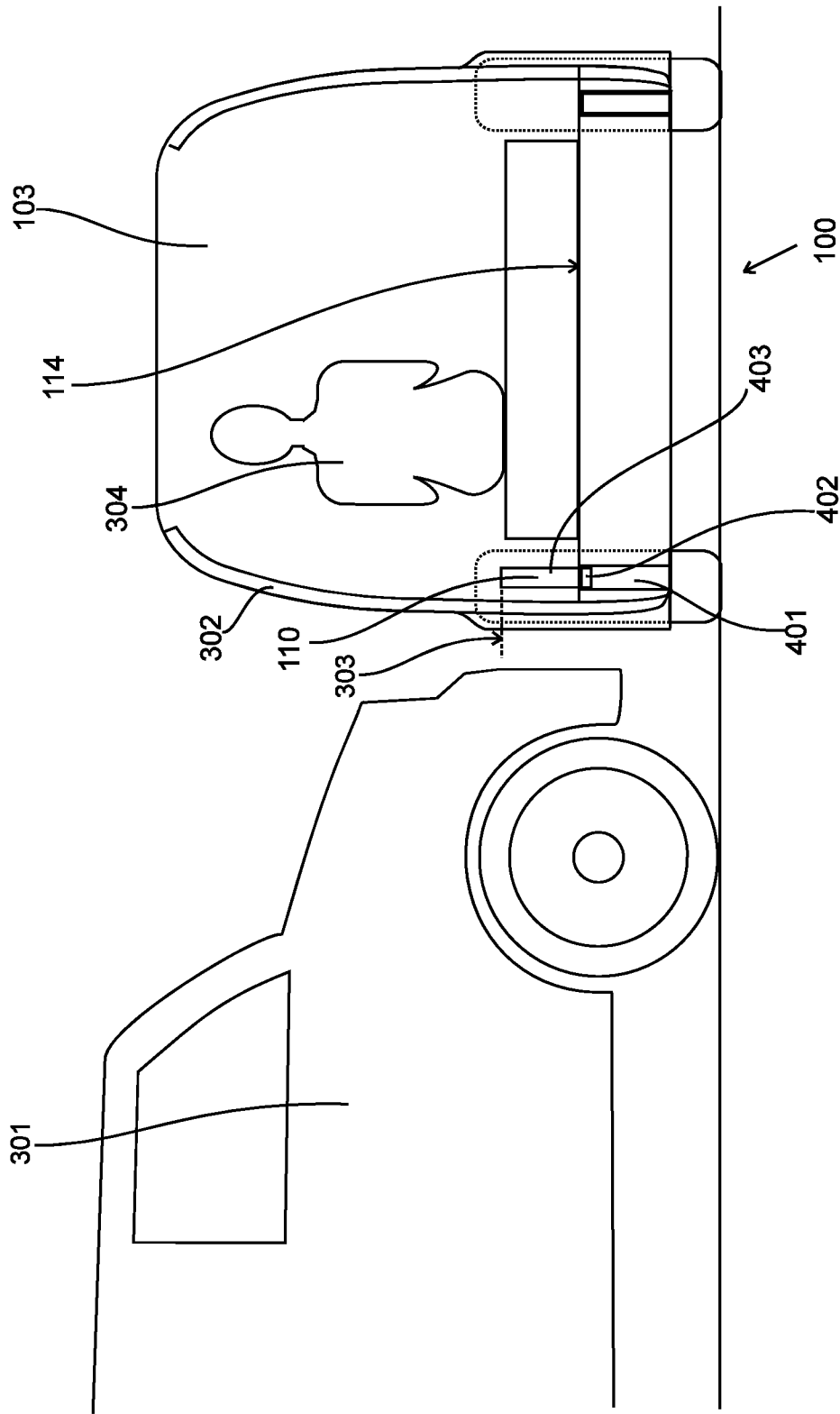


Fig. 3

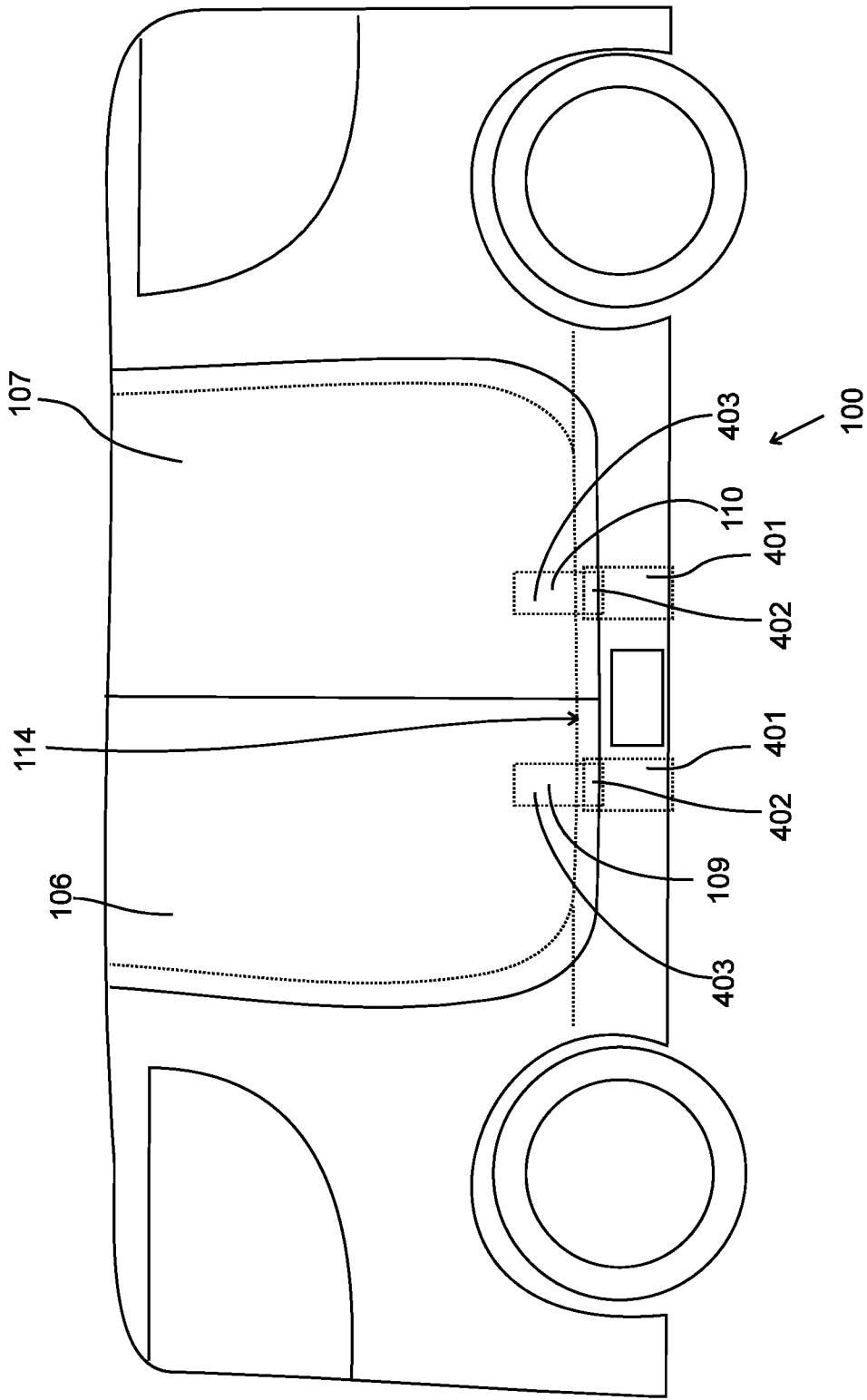


Fig. 4

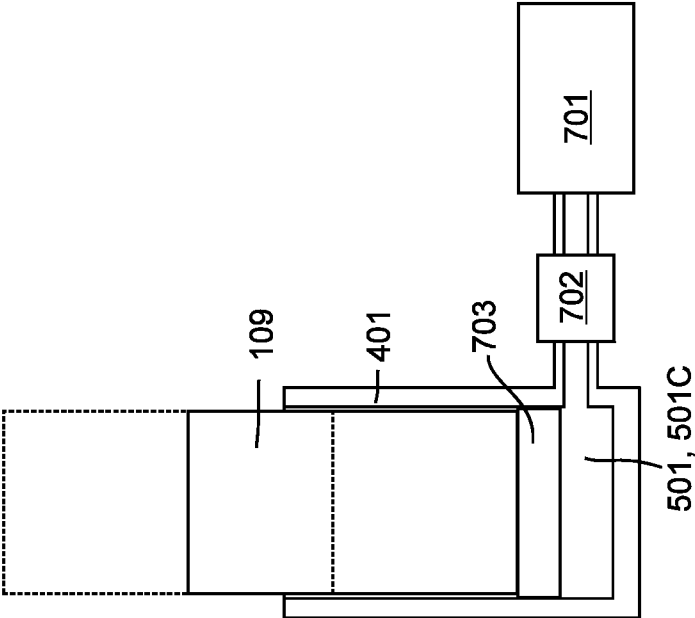


Fig. 5

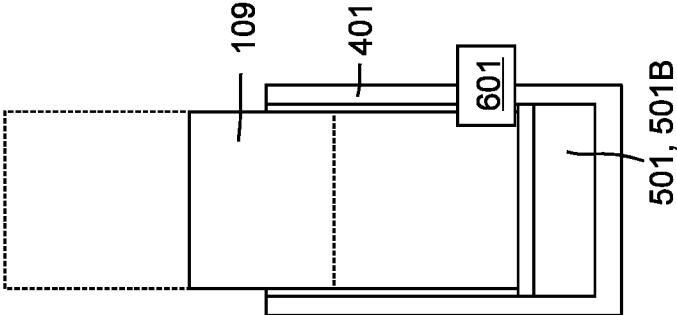


Fig. 6

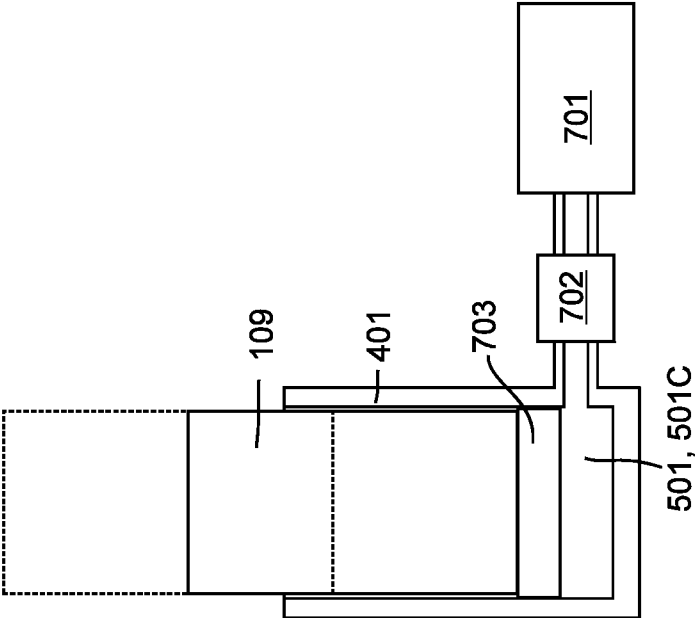


Fig. 7

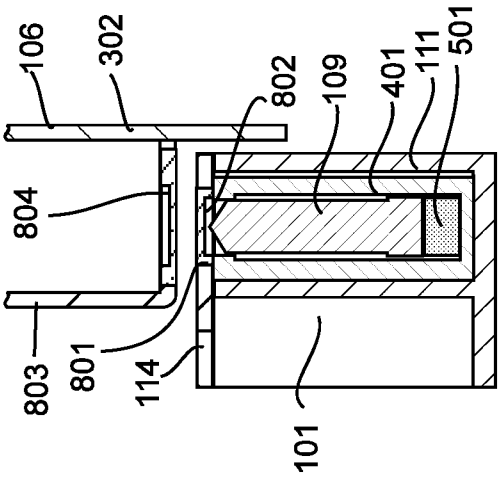


Fig. 8B

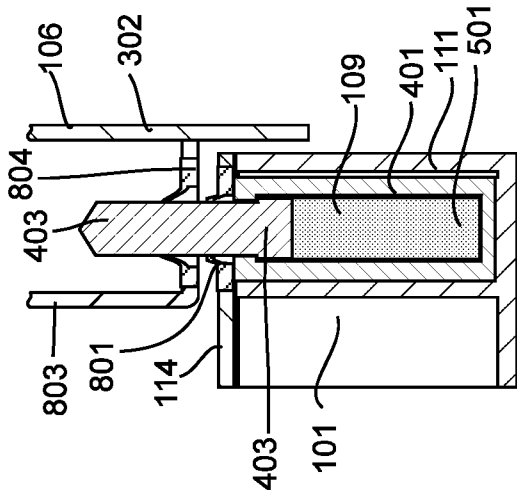


Fig. 9B

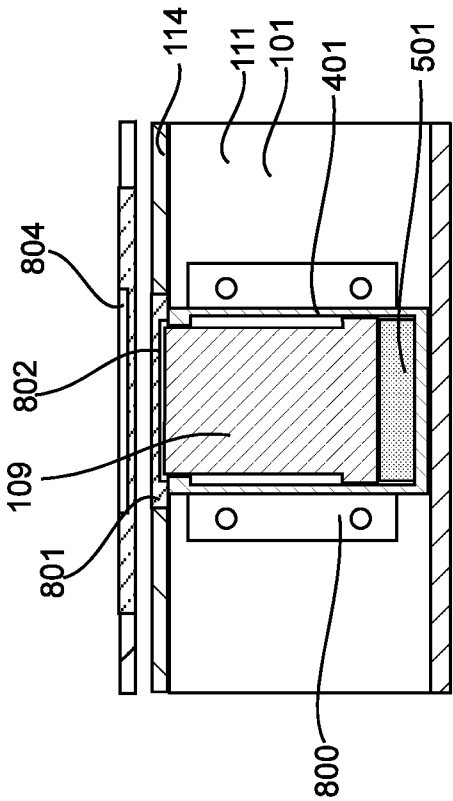


Fig. 8A

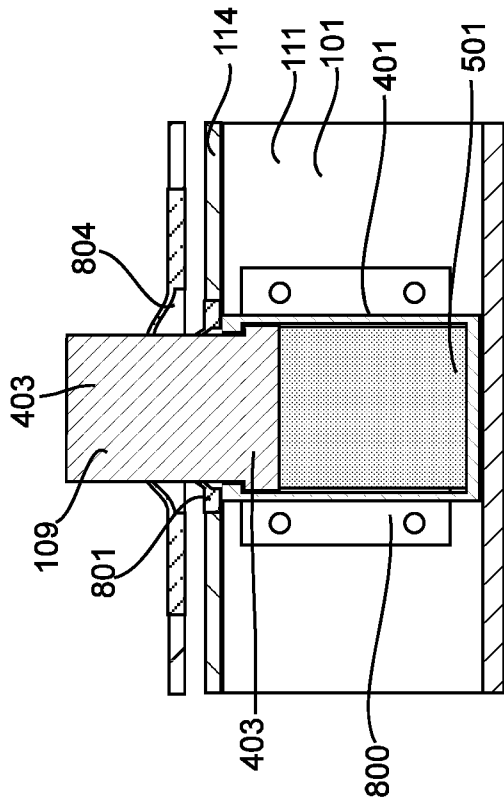


Fig. 9A

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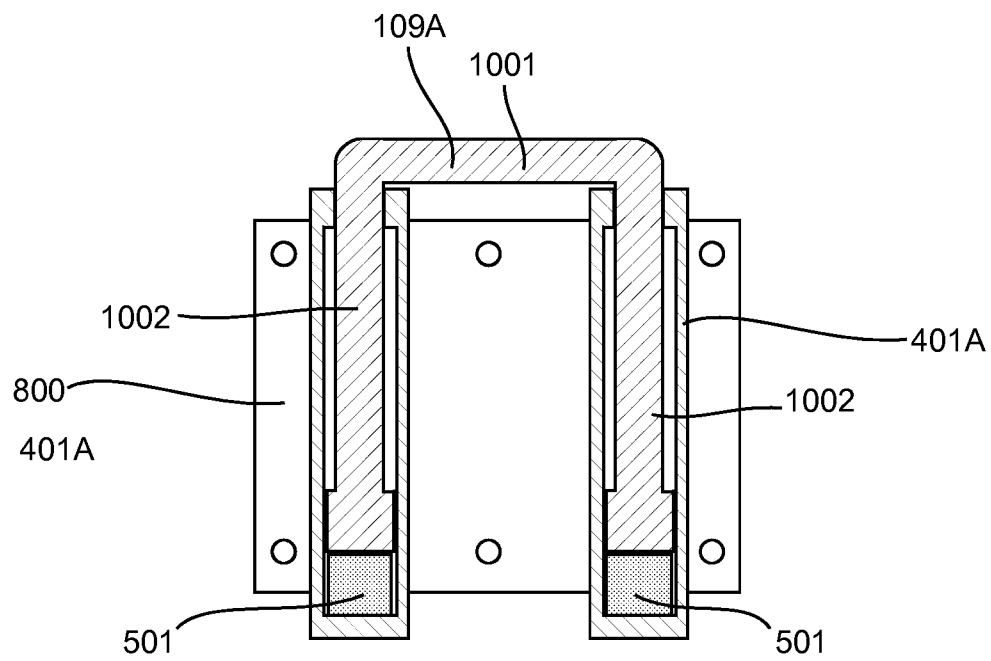


Fig. 10A

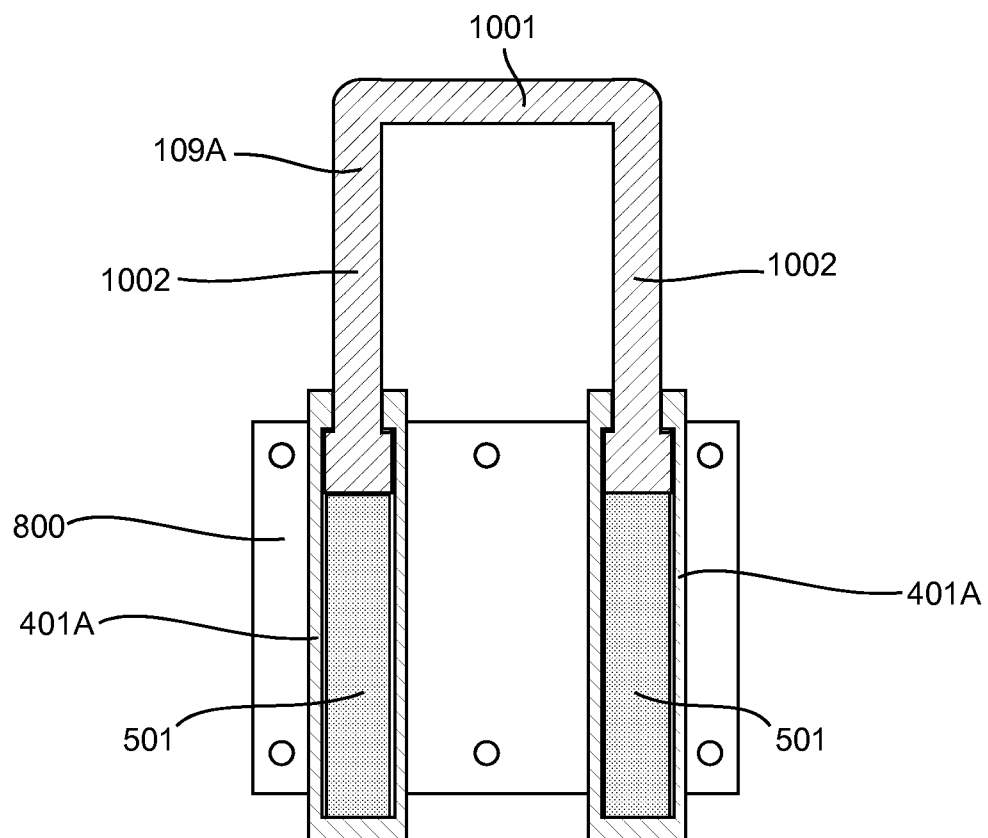


Fig. 10B

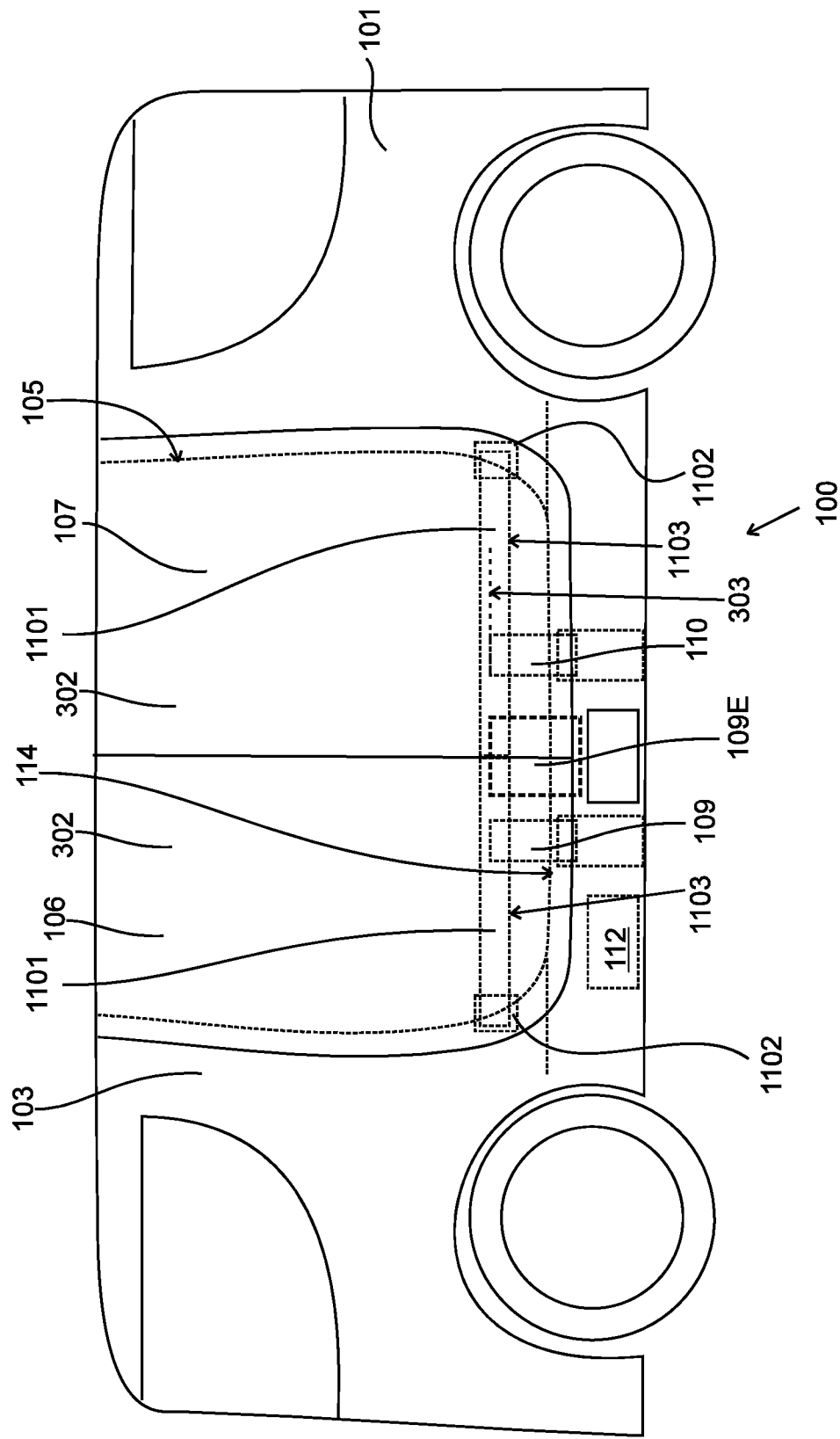


Fig. 11

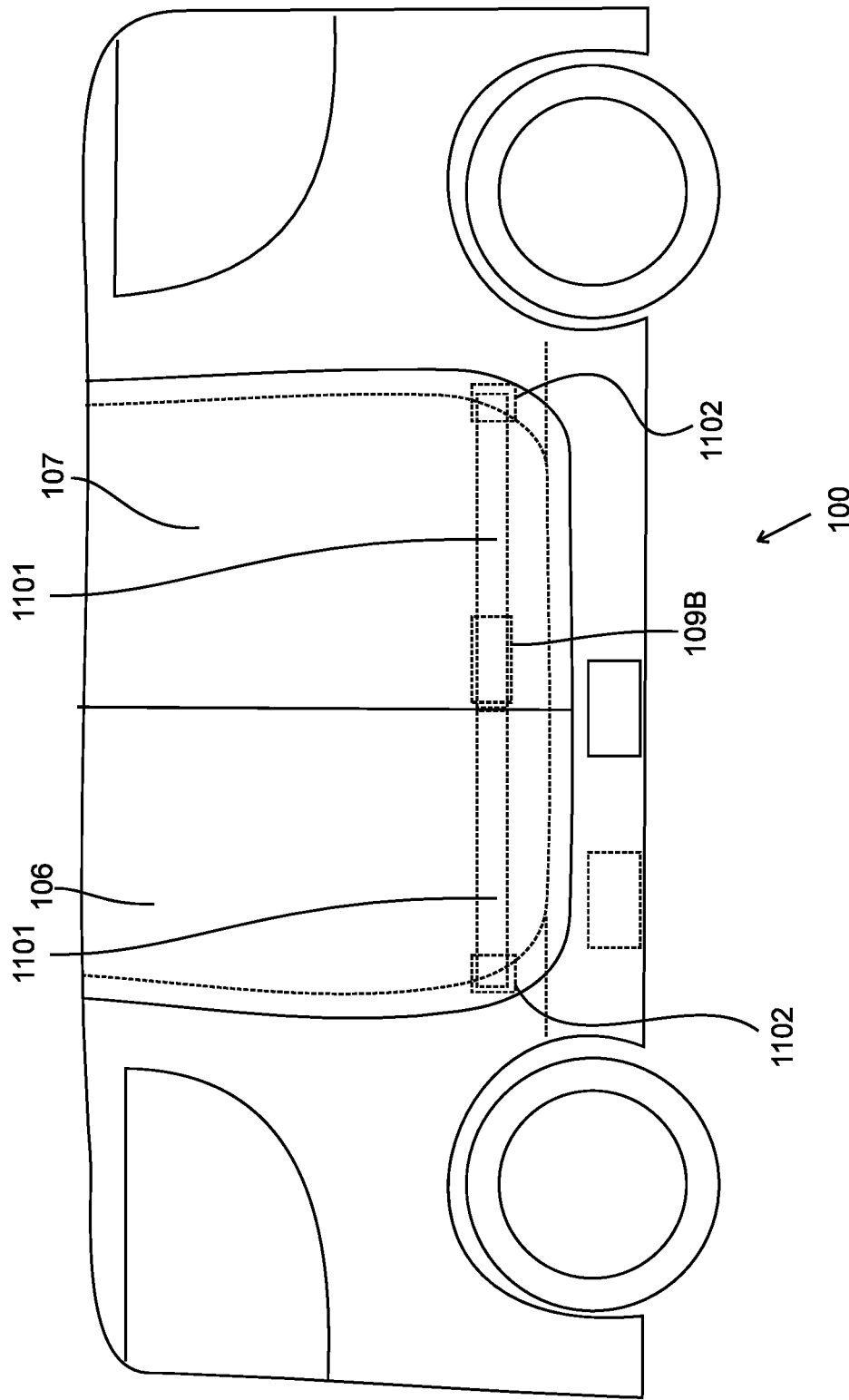


Fig. 12

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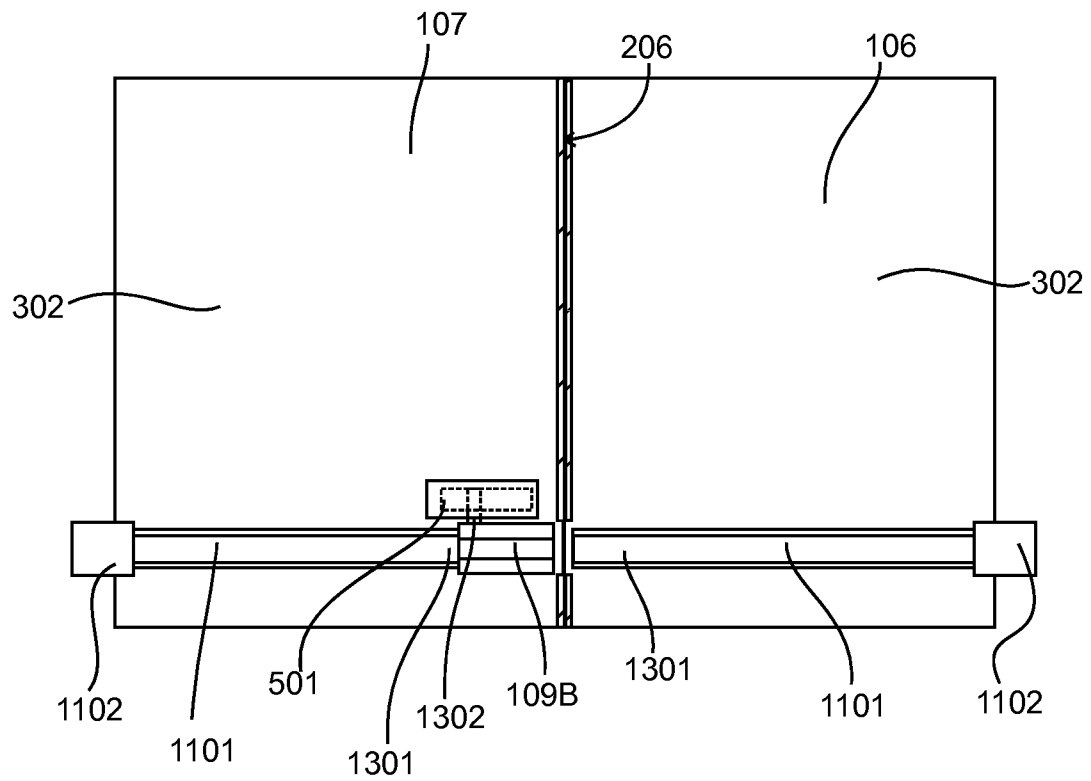


Fig. 13

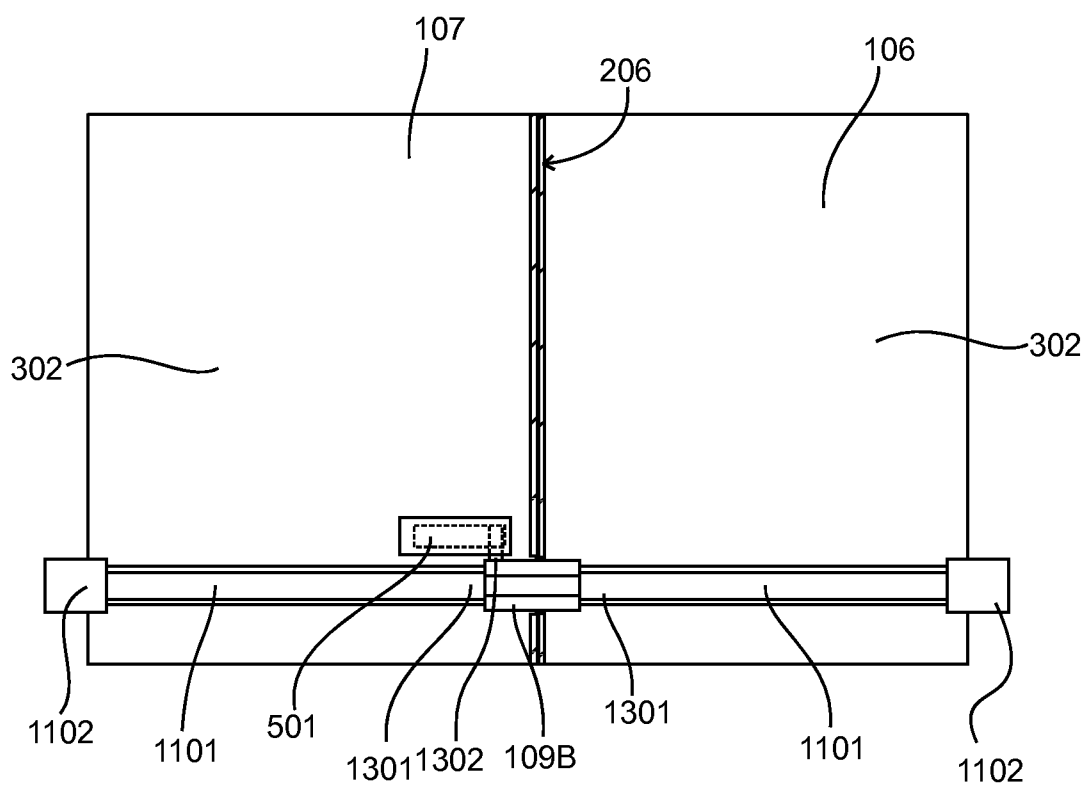


Fig. 14

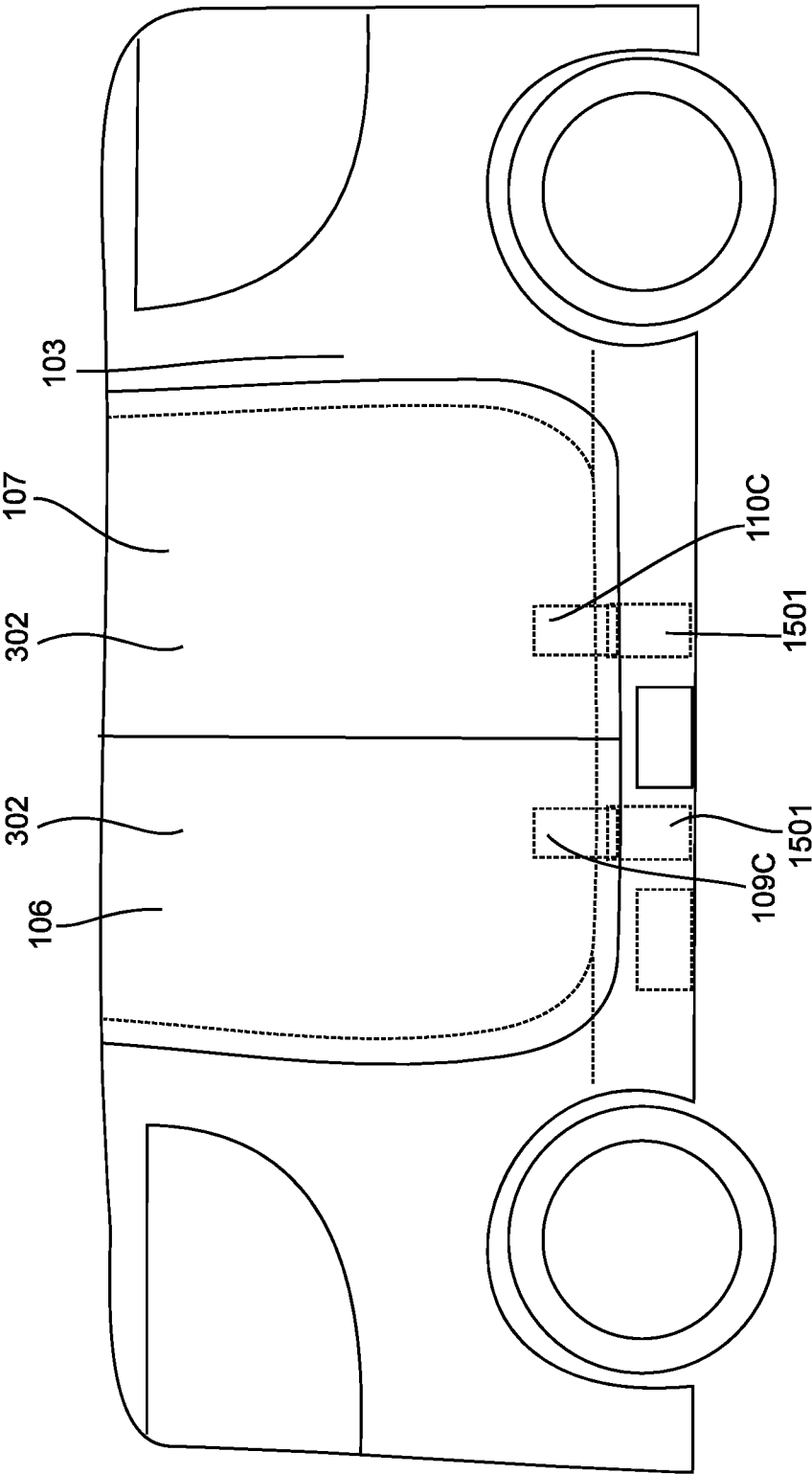


Fig. 15

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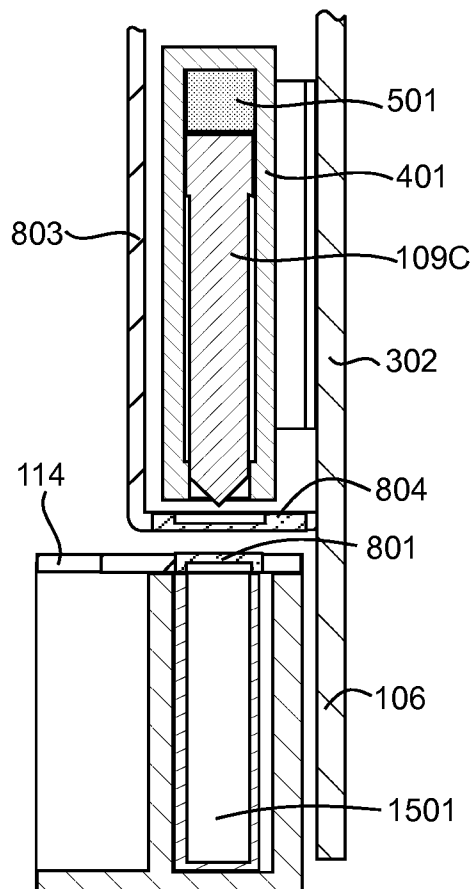


Fig. 16A

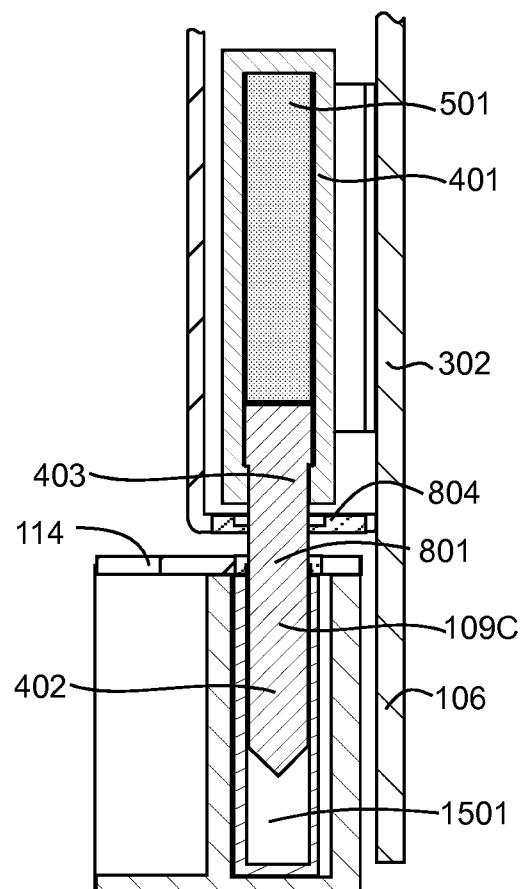


Fig. 16B

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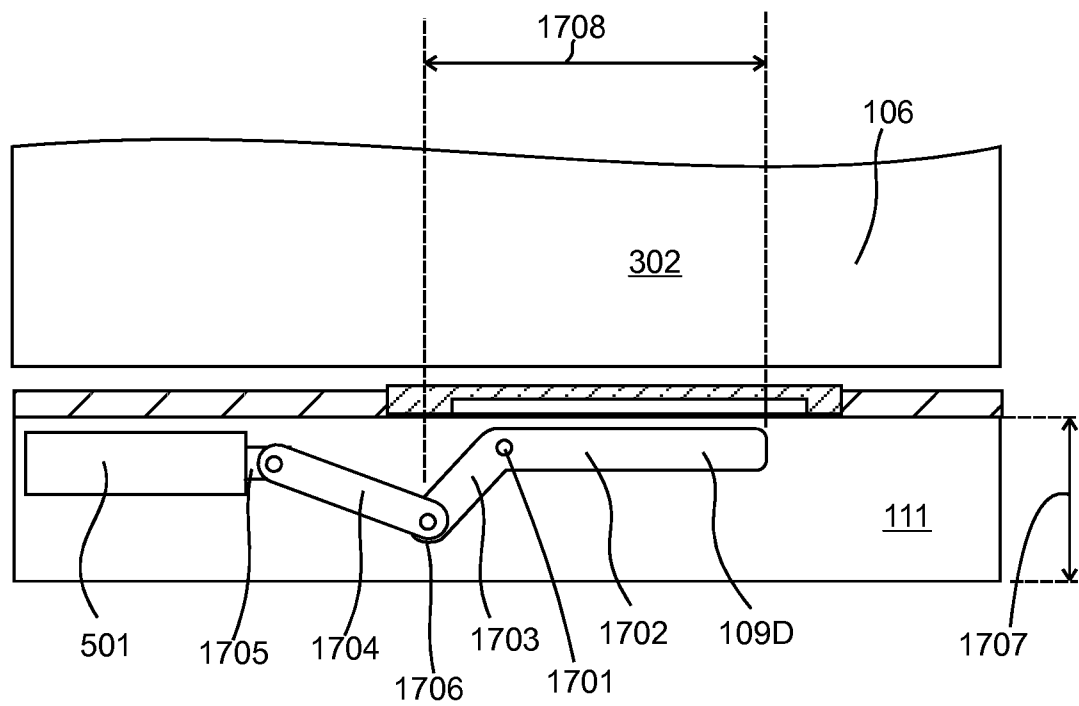


Fig. 17

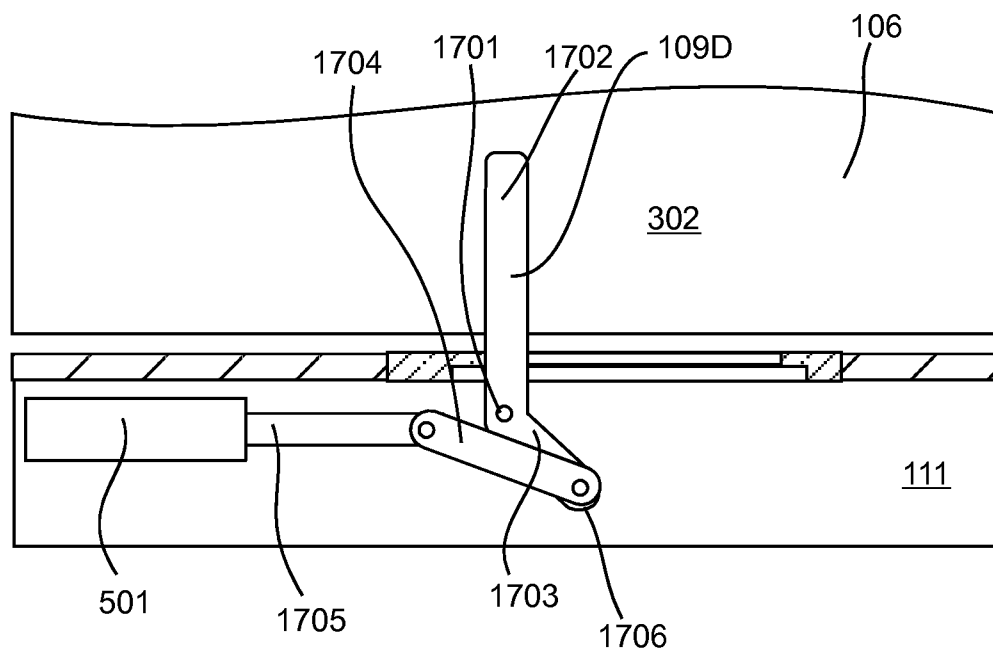


Fig. 18

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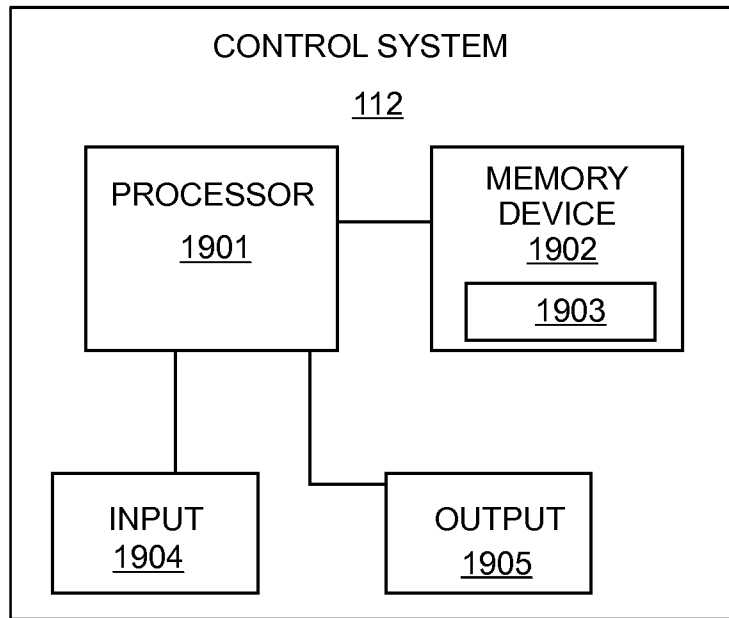


Fig. 19

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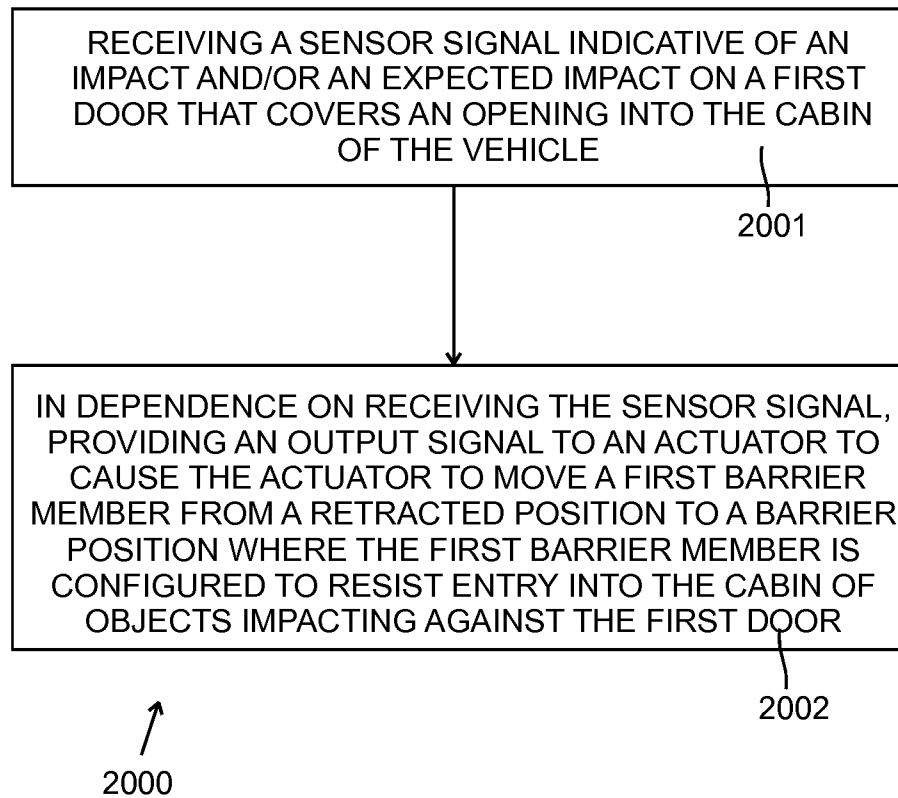


Fig. 20

INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2019/078284

A. CLASSIFICATION OF SUBJECT MATTER

INV. B60J5/04

ADD. B60J5/06

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

B60J B60R

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DE 10 2017 005759 A1 (DAIMLER AG [DE]) 14 December 2017 (2017-12-14)	1-5,9, 11,13, 15,16, 21-25 10,20
A	paragraphs [0009] - [0015] paragraph [0023] - paragraph [0028] figures 1-5	
X	US 2018/265027 A1 (NUSIER SAIED [US] ET AL) 20 September 2018 (2018-09-20) paragraph [0016] - paragraph [0068] figures 1-5, 10-14 ----- -/-	1,2,4, 13-15, 17-19, 22-25



Further documents are listed in the continuation of Box C.



See patent family annex.

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

23 January 2020

Date of mailing of the international search report

31/01/2020

Name and mailing address of the ISA/

European Patent Office, P.B. 5818 Patentlaan 2
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Fax: (+31-70) 340-3016

Authorized officer

Heijnen, Philip

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2019/078284

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
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Information on patent family members

International application No

PCT/EP2019/078284

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